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Original Article

Influence of Soilless and Soil-based nursery media on emergence and early seedling growth of Pawpaw (*Carica papaya* L.)

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ABSTRACT

Providing alternative sources of nursery media compositions is important to reduce soil mining which causes soil erosion, land degradation and nutrient leaching. This study evaluated soil-based and soilless-based nursery media on emergence, early growth and dry matter accumulation of pawpaw seedlings for two cropping seasons. Materials utilized for the nursery media were topsoil (TS), poultry manure (PM), river sand (RS), sawdust (SD) and rice husk (RH). Eight nursery media were composted and evaluated namely: TS+PM+RS (3:2:1), TS+PM+RS (1:2:3), RS+PM+SD (3:2:1), RS+PM+SD (1:2:3), RH+PM+SD (1:1:1), topsoil (100%), RH+PM (3:1) and SD+PM (3:1). These were laid in a completely randomized design in five replications. The findings revealed that the nursery media had significant (P<0.05) influence on emergence and growth parameters of pawpaw seedlings. TS+PM+RS (3:2:1) enhanced earliest days to 100% emergence (15 days in 2022) but this value did not significantly vary with 18-21 days obtained with RS+PM+SD (3:2:1), RH+PM+SD (1:1:1), RH+PM (3:1) and SD+PM (3:1). Seedlings from RS+PM+SD (3:2:1) and RS+PM+SD (1:2:3) at 10 weeks after emergence significantly produced more leaves (9.47%, 19.29% and 27.03%, 13.42%), in 2022 and 2023, respectively compared to TS+PM+RS (3:2:1). Seedlings from RH+PM+SD (1:1:1) medium consistently allocated highest (45% and 62.4%) dry matter to the leaves in 2022 and 2023, respectively. It was therefore concluded that the investigated soilless-based nursery media particularly RS+PM+SD (3:2:1), RS+PM+SD (1:2:3), RH+PM+SD (1:1:1) and RH+PM (3:1) nursery media can serve as alternatives to the commonly utilized soil-based media (topsoil and TS+PM+RS) for production of vigorous pawpaw seedlings.

KEYWORDS: *Juvenile, Pawpaw, Seedling development, Soil mining, Substrate, Sustainable*

INTRODUCTION

Carica papaya, commonly known as pawpaw, is a tropical fruit crop of significant economic value, prized for its nutritional benefits and versatility in culinary applications (Nafiu *et al.*, 2019). The cultivation of pawpaw offers opportunities for agricultural prosperity and market diversification in tropical and subtropical regions. However, the successful establishment of pawpaw orchards largely depends on the quality of seedlings produced in nurseries (Ephraim and Abubakar, 2018). Despite the high global demand for pawpaw fruits due to their recognized health benefits (Wong *et al.*, 2023), limited seedling vigor poses a constraint to increased production, particularly in countries like Nigeria with high production potential. The germination of pawpaw seeds is often slow, erratic, and incomplete (Bhardwaj, 2014), necessitating careful attention to nursery practices to improve seedling vigor (Kandasamy *et al.*, 2020).

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Furthermore, the reliance on soil-based media for nurseries raises concerns about soil degradation from excavation. The continuous extraction of topsoil for nursery media can lead to erosion, ecosystem degradation, and an increased risk of landslides. This poses an environmental threat and calls for use of other alternatives that could be locally available, environmentally friendly and cost-effective during seedling production in the nursery. Raising of seedlings is an important aspect in the efficient production of many crops as it gives the opportunity to select vigorous and disease-free seedlings for transplanting as well as provides uniformity of transplant. However, nursery media form major determinant factor to successful production of vigorous seedlings. The composition of growth media plays a crucial role in seed germination and seedling quality (Wilson *et al.,* 2001). Generally, an ideal growth medium provides anchorage, nutrients, water, and allows for proper gaseous exchange (Abad *et al.,* 2002).

The present study aims to address these challenges by investigating the effects of various nursery media, including underutilized materials such as rice husk and sawdust which are available in abundance in Anambra State. Rice husk, a byproduct of rice milling is usually heaped around rice mills in Ayamelum Local Government Area of Anambra State and constitutes environmental pollution. In addition, sawdust, a by-product of wood, obtained from operations during woodworking operations (Mallakpour *et al*., 2021) are found in abundance and relatively cheap with disposal problem in saw mills found within the state, especially Awka metropolis. An earlier report by Mallakpour *et al*. (2021) noted that sawdust is an abundant and inexpensive material with disposal challenges over the past decade. These materials can be recycled for other important uses. Specifically, this research sought to determine the impact of utilizing available, accessible and affordable materials in the study area (sawdust and rice husk) as components of nursery media on the emergence and juvenile growth of pawpaw seedlings.

MATERIALS AND METHODS

Experimental Site: The experiment was conducted at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. Precisely, the site is situated at latitude 6°14'53.45736 N and longitude 7°7'10.76592 E. The site is also characterized by a tropical rainforest climate with temperatures ranging from 27°C to 30°C and an average annual rainfall of 1677.70 – 3863.40 mm (Omoja *et al*., 2021).

Planting Materials: Seeds of Red Royal pawpaw variety were utilized. A total of 160 seeds were planted in poly pots (40 x 80 cm) containing different nursery media.

Treatments and Experimental Design: The treatments comprised various combinations of nursery media. Materials utilized for the nursery media were topsoil (TS), poultry manure (PM), river sand (RS), sawdust (SD) and rice husk (RH). Eight nursery media were composted and evaluated namely TS+PM+RS (3:2:1), TS+PM+RS (1:2:3), RS+PM+SD (3:2:1), RS+PM+SD (1:2:3), RH+PM+SD (1:1:1), topsoil (100%), RH+PM (3:1) and SD+PM (3:1). These were laid out in a completely randomized design (CRD) with five replications.

Physico-chemical compositions of these nursery media were determined. Particle size (sand, silt and clay contents) of the media was determined by hydrometer method using sodium hexameta phosphate (calgon) as dispersing agent and as described by Gee & Or (2002). Organic carbon was determined by chromic acid wet oxidation method as described by Nelson & Sommers (1982) while the total nitrogen was determined using the micro Kjeldahl method described by Bremner & Mulvaney (1982). The exchangeable bases (calcium, magnesium, potassium and sodium) were extracted in 1N-NH4OAC buffered at pH 7. Thereafter, the concentration determinations of the exchangeable bases were done with Atomic Absorption Spectrophotometer.

Nursery Practices and Management: Topsoil was collected from a plantain plantation at the at a depth of 0–20 cm. Poultry manure was obtained from a battery cage system, while river sand was obtained from a building site within the University. Saw dust was obtained from a saw mill while the rice husk was collected from a rice mill all in Anambra state.

Nursery Preparation and Seed sowing: A nursery shade was constructed and a total of 40 poly bags of (40 cm x 80 cm) was placed accordingly. The different nursery media was potted in the poly pots with five replications for each nursery media. The potted media was placed under the nursery shade at a spacing of 1m between the rows and 0.5m within rows (1 m x 0.5 m). Thereafter, the seeds were sown at a depth of 5 cm. Six seeds were planted per poly bag in a circular arrangement.

Weeding and Irrigation: Weeds were removed manually from the nursery as they appeared. In addition, the media were irrigated daily with 1.5 liters of water. However, the poly bags were first irrigated to container capacity before the seeds were sown.

Data Collection: The phenological data determined were days to first emergence (number of days from sowing to first seedling emergence), days to 50% emergence (number of days from the first emerged seedling till half of the seedling in each treatment emerged) and days to 100% emergence (number of days from sowing till emergence of all the seedlings.

Growth data included the total number of leaves per plant, seedling height (measured from soil level to the shoot apex in centimeters using a flexible meter rule), and stem diameter (measured with a vernier caliper at 10 cm above the soil level). These growth parameters were recorded at 2, 4, 6, 8, 10 and 12 weeks after seedling emergence (WAE).

Data Analysis: All the data collected were subjected to analysis of variance using GENSTAT (2012) statistical package according to the procedure outlined for completely randomized design (CRD). Separation of treatment means was done using least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Physicochemical properties of nursery media utilized during the study

The organic carbon content varied considerably among the samples, ranging from 0.02% (Topsoil 100%) to 0.12% (RS + PM + SD; 1:2:3) for the 2022 season, and from 0.02% (TS + PM + RS; 3:2:1) to 0.10% (RS+PM+SD; 1:2:3) for the 2023/2024 session (Table 1). These values are typical for mineral soils and can significantly influence soil fertility. The variation in organic carbon content across samples could be attributed to differences in the source materials, decomposition rates, and management practices. Higher organic carbon content generally indicates better soil quality, as it contributes to improved water retention, nutrient availability, and microbial activity.

Notably in 2022, nursery media, RS+PM+SD (1:2:3) exhibited the highest phosphate concentration (4.31mg/g) followed by TS+PM+RS (1:2:3) which contained 3.06 mg/g of phosphate. Similarly, in 2023/2024, RS + PM + SD (1:2:3) had the highest phosphate concentrations of 3.23 mg/g followed by RH+PM+SD (1:1:1) with 1.61 mg/g of phosphate. This suggests diverse nutrient statuses among the nursery media. The highest nitrogen content was found in nursery medium, RH + PM (3:1) (2.03%) followed by TS + PM + RS (3:2:1) (1.24%) in 2022 cropping season but in 2023/2024, highest nitrogen percentage (0.9%) was recorded in RH + PM + SD (1:1:1).

The magnesium (Mg), potassium (K), and calcium (Ca) concentrations across different nursery media mixtures revealed notable variations both within combinations and between growing seasons (Table 1). In 2022, TS+PM+RS (3:2:1) showed the highest Mg content (0.344 mg/kg), while SD+PM (3:1) recorded the highest K level (0.325 mg/kg). In 2023/2024 season, SD+PM (3:1) exhibited highest Mg concentration (0.398 mg/kg), while RH+PM+SD (1:2:3) contained highest Ca levels (0.318 mg/kg). The topsoil (100%) maintained relatively stable nutrient levels across both seasons, with slight variations in Mg (0.208 to 0.215 mg/kg), K (0.192 to 0.228 mg/kg), and Ca (0.176 to 0.213 mg/kg). Notably, RH+PM (3:1) consistently showed low nutrient concentrations, particularly for K (0.101 and 0.148 mg/kg) across both seasons, which suggested potential limitations in nutrient retention capacity.

Seedling Emergence

The nursery media had a significant ($P<0.05$) effect on the days to first emergence, 50% emergence, 100% emergence, and average days to emergence of pawpaw seedlings in both experimental years (2022 and 2023-2024) (Table 2). In the 2022 planting season, the topsoil (100%) medium recorded the earliest days to first emergence (11.39 days), and 50% emergence (9.75 days), which were significantly ($P<0.05$) different from other media. However, the TS+PM+RS (3:2:1) medium had the latest days to 100% emergence (14.50 days) and average days to emergence (15.00 days), although not significantly ($P>0.05$) different from the topsoil medium.

In the 2023-2024 season, the TS+PM+RS (3:2:1) medium also recorded the least days to 100% emergence (18.00 days) and average days to emergence (19.00 days), which were significantly ($P<0.05$) different from other media. The RH+PM+SD (1:1:1) medium had the highest days to 100% emergence (35.98 days), which was significantly ($P<0.05$) higher than other media. However, the RS+PM+SD (3:2:1) medium had the highest average days to emergence (34.00 days), which was significantly ($P<0.05$) higher than other media.

The TS+PM+RS (3:2:1) medium demonstrated optimal performance, which can be attributed to its balanced particle size distribution (77.77-85.52% coarse powder). This finding aligns with Caron *et al*. (2010), who emphasized that ideal growing media should maintain coarse particles to ensure adequate aeration and drainage. The superior performance of this mixture is further supported by Isa *et al*. (2021), who reported that balanced proportions of topsoil and organic amendments enhance both physical and chemical properties of nursery substrates. The 100% topsoil, while showing consistent nutrient levels across seasons (0.208-0.215 mg/kg of Mg), exhibited lower coarse particle content (64.35-67.82%), potentially affecting aeration. According to Chapman *et al*. (2012), this physical characteristic could influence root development and nutrient uptake efficiency.

Media containing higher proportions of rice husk and sawdust showed higher coarse particle percentages (>87%) but generally lower nutrient concentrations, particularly in K (0.101-0.148 mg/kg for RH+PM, 3:1). This observation corresponds with findings by Nwite *et al*. (2012), who noted that while organic materials like rice husk improve physical properties, they might require supplemental nutrition for optimal plant growth. The seasonal variations in nutrient concentrations, particularly the increase in K levels during 2023/2024, could be attributed to the decomposition dynamics of organic components, as suggested by Quaye *et al*. (2015). These findings highlight the importance of balancing both physical and chemical properties in nursery media composition, supporting previous research on the interaction between substrate characteristics and seedling development.

Table 1: Some physicochemical properties of nursery media utilized

Properties	TS+PM+RS (3:2:1)	TS+PM+RS (1:2:3)	RS+PM+SD (3:2:1)	RS+PM+SD (1:2:3)	RH+PM+SD (1:1:1)	Topsoil 100%	SD+PM (3:1)	RH+PM (3:1)
	2022							
Sand (%)	77	84	94	90	88	68	91	90
Clay (%)	8	6	4	7	6	14	4	5
Silt (%)	15	10	2	3	6	18	5	5
Textural class	Sandy loam	Loamy sand	Sandy	Sandy	Loamy sand	Sandy loam	Sandy	Sandy
Organic carbon (%)	0.09	0.06	0.04	0.12	0.07	0.02	0.03	0.08
Phosphate conc. (mg/kg)	1.44	3.06	2.49	4.31	0.23	0.99	0.21	0.02
Nitrogen (%)	1.24	0.37	0.67	0.76	0.57	0.23	0.57	2.03
Magnesium (cmol/100g)	0.344	0.329	0.118	0.214	0.261	0.208	0.215	0.188
Potassium (cmol/100g)	0.233	0.198	0.187	0.119	0.116	0.192	0.325	0.101
Calcium (cmol/100g)	0.332	0.243	0.197	0.148	0.143	0.176	0.225	0.243
	2023/2024							
Sand (%)	86	93	89	88	87	64	80	88
Clay (%)	6	3	8	6	3	12	2	4
Silt (%)	8	4	3	6	10	24	18	8
Textural class	Loamy sand	Sandy	Sandy	Loamy sand	Loamy sand	Sandy loam	Loamy sand	Sandy
Organic carbon (%)	0.02	0.07	0.10	0.06	0.07	0.05	0.05	0.03
Phosphate conc. (mg/kg)	0.72	0.37	1.33	3.23	1.61	0.58	0.34	1.44
Nitrogen (%)	0.63	0.63	0.53	0.58	0.90	0.09	0.70	0.07
Magnesium (cmol/100g)	0.231	0.190	0.198	0.208	0.221	0.215	0.398	0.231
Potassium (cmol/100g)	0.332	0.312	0.299	0.333	0.265	0.228	0.127	0,148
Calcium (cmol/100g)	0.176	0.213	0.218	0.318	0.294	0.213	0.199	0.187

TS+PM+RS = Topsoil+Poultry Manure+Riversand; RS+PM+SD = Riversand+Poultry Manure+Sawdust; RH+PM+SD = Ricehusk+Poultry Manure+Sawdust; RH+PM = Ricehusk+Poultry Manure; SD+PM = Sawdust+Poultry Manure

Table 2: Days to first, 50% and 100% emergence as influenced by nursery media

Nursery Media	2022 Days to first emergence	2022 Days to 50% emergence	2022 Days to 100% emergence	2023-2024 Days to first emergence	2023-2024 Days to 50% emergence	2023-2024 Days to 100% emergence
TS+PM+RS (3:2:1)	12.40	11.60	14.50	15.52	16.00	18.00
TS+PM+RS (1:2:3)	16.53	13.80	24.67	19.23	19.00	26.50
RS+PM+SD (3:2:1)	15.64	16.80	20.77	24.75	30.40	25.25
RS+PM+SD (1:2:3)	16.35	14.00	28.96	23.05	24.75	21.00
RH+PM+SD (1:1:1)	20.76	19.60	20.77	27.46	29.20	35.98
Topsoil (100%)	11.39	9.75	18.01	15.25	18.50	20.01
RH+PM (3:1)	11.88	10.40	17.75	20.60	20.20	29.99
SD+PM (3:1)	19.66	23.25	20.77	30.15	30.00	25.25
$LSD_{0.05}$	4.63	5.70	7.76	6.15	7.21	15.93

TS+PM+RS = Topsoil + Poultry Manure + River-sand; RS+PM+SD = River-sand +Poultry Manure + Sawdust; RH+PM+SD = Rice-husk + Poultry Manure + Sawdust; RH+PM = Rice-husk + Poultry Manure; SD+PM = Sawdust + Poultry Manure

Seedling Height of Pawpaw

Nursery media had a significant ($P<0.05$) effect on the plant height of pawpaw seedlings at 4, 6, 8 and 10 weeks after emergence (WAE) in both experimental years (Table 3). In 2022 planting season, the TS+PM+RS (3:2:1) medium produced the tallest seedlings at 4 WAE (27.27 cm), 6 WAE (43.4 cm), 8 WAE (59.5 cm), and 10 WAE (92.5 cm). However, the seedling height was not significantly ($P>0.05$) different from the values obtained from TS + PM + RS (1:2:3) medium, especially at 6, 8 and 10 WAE. Shortest seedlings were produced from 100% topsoil at 6 and 8 WAE and from SD + PM (3:1) medium at 10 WAE.

In the 2023-2024 planting season, the TS+PM+RS (3:2:1) medium also produced the tallest seedlings at 4 WAE (12.63 cm), 6 WAE (26.20 cm), 8 WAE (34.20 cm), 10 WAE (57.7 cm), and 12 WAE (64.6 cm), whereas shortest seedlings were obtained from RH + PM (3:1) medium, especially at 10 and 12 WAE.

This superior performance of TS+PM+RS (3:2:1) in terms of seedling height could be attributed to the balanced nutrient composition and favourable physical properties provided by the combination of these components (Adubasim *et al*., 2018).

Table 3: Seedling height (cm) of pawpaw as influenced by nursery media at 4, 6, 8 and 10 weeks after emergence

Nursery Media	2022				2023-2024				
	4 WAE	6 WAE	8 WAE	10 WAE	4 WAE	6 WAE	8 WAE	10 WAE	12 WAE
TS+PM+RS (3:2:1)	27.27	43.4	59.5	92.5	12.63	26.20	34.20	57.7	64.6
TS+PM+RS (1:2:3)	15.92	36.7	57.9	86.8	7.13	9.81	12.47	30.3	36.4
RS+PM+SD (3:2:1)	12.01	23.1	40.9	77.8	7.45	8.80	11.06	28.1	34.6
RS+PM+SD (1:2:3)	8.27	24.0	41.2	74.7	6.40	9.39	7.52	23.7	27.2
RH+PM+SD (1:1:1)	8.48	25.9	43.3	78.4	6.46	12.31	8.10	18.8	22.8
Topsoil (100%)	17.44	19.4	31.6	54.4	7.67	10.67	11.18	20.0	25.0
RH+PM (3:1)	11.79	34.7	52.6	56.9	5.21	9.40	6.12	7.8	10.0
SD+PM (3:1)	7.62	25.6	38.5	42.3	4.44	9.12	6.65	24.0	26.1
$LSD_{0.05}$	6.45	10.13	15.99	17.13	2.36	4.61	4.17	9.98	10.66

TS+PM+RS = Topsoil+Poultry Manure+Riversand; RS+PM+SD = Riversand+Poultry Manure+Sawdust; RH+PM+SD = Ricehusk+Poultry Manure+Sawdust; RH+PM = Ricehusk+Poultry Manure; SD+PM = Sawdust+Poultry Manure

Topsoil is a rich source of essential nutrients and beneficial microorganisms, while poultry manure contributes organic matter, nitrogen, phosphorus, and other plant nutrients (Singh *et al*., 2020). The inclusion of river sand likely improved aeration, drainage, and root zone conditions, facilitating optimal growth (Bunt, 2012). The synergistic effects of these components in the TS+PM+RS (3:2:1) medium created an ideal environment for vigorous seedling growth.

In contrast, the media containing high proportions of sawdust or rice husk, such as the RH+PM (3:1) and SD+PM (3:1) media, consistently produced the shortest seedlings across most growth stages. This could be due to the high carbon-to-nitrogen ratio and potential nitrogen immobilization caused by the decomposition of these organic materials as noted by Trillas *et al*. (2006). Nitrogen deficiency can stunt plant growth and result in reduced plant height (Sun *et al*., 2020).

Number of Leaves of Pawpaw

The nursery media had significant ($P<0.05$) influence on the number of leaves produced by the pawpaw seedlings at 4, 6, 8, and 10 weeks after emergence (WAE) in both experimental years (Table 4). In 2022 planting season, the TS+PM+RS (3:2:1) medium significantly ($P<0.05$) produced seedlings with the highest number of leaves at 4 WAE (10.57), whereas highest number of leaves were observed in RH + PM (3:1) medium at 6 WAE (11.54) and 8 WAE (13.53). However, at 10 WAE, the RS+PM+SD (1:2:3) medium produced highest number of leaves (13.73). Fewest number of leaves was obtained from topsoil medium at 6, 8 and 10 WAE.

Similarly, in 2023-2024, the TS+PM+RS (3:2:1) medium produced seedlings with highest number of leaves at 6 WAE (10.47), 8 WAE (11.72), and 12 WAE (12.01) followed by RS + PM + SD (3:2:1) medium especially at 4 WAE since the number of leaves was not significantly ($P>0.05$) different from the RS+PM+SD (3:2:1) medium. At 10 and 12 WAE, the TS+PM+RS (1:2:3) medium produced seedlings with the highest number of leaves (14.43), which was significantly ($P<0.05$) higher than other media. The second best according to higher production of leaves was RS + PM + SD (3:2:1) medium. RH+PM (3:1) medium consistently produced seedlings with the lowest number of leaves across most growth stages in all the sampling periods in 2023-2024 followed by the topsoil.

Generally, the TS+PM+RS (3:2:1) medium demonstrated superior performance in promoting leaf production and early vegetative growth of pawpaw seedlings across most growth stages in both experimental years. The TS+PM+RS (3:2:1) medium consistently produced seedlings with the highest number of leaves across most growth stages in both experimental years. This superior performance could be attributed to the balanced nutrient composition and favourable physical properties such as good aeration and moisture retention provided by the combination of the nursery medium component as observed.

Table 4: Number of leaves of pawpaw as influenced by nursery media at 4, 6, 8 and 10 weeks after emergence

	2022				**2023-2024**				
Nursery Media	**4 WAE**	**6 WAE**	**8 WAE**	**10 WAE**	**4 WAE**	**6 WAE**	**8 WAE**	**10 WAE**	**12 WAE**
TS+PM+RS (3:2:1)	10.57	11.40	12.40	11.51	6.80	10.47	11.72	10.73	12.01
TS+PM+RS (1:2:3)	8.98	10.20	11.62	11.33	5.36	7.85	8.26	14.43	15.75
RS+PM+SD (3:2:1)	8.50	8.94	10.85	12.60	5.90	6.96	7.06	13.63	14.98
RS+PM+SD (1:2:3)	7.27	8.99	13.04	13.73	3.85	6.39	5.94	12.17	13.69
RH+PM+SD (1:1:1)	6.40	7.98	11.79	11.54	3.78	7.19	5.08	10.53	11.07
Topsoil (100%)	10.41	7.34	9.28	9.54	5.33	8.47	7.25	8.69	9.52
RH+PM (3:1)	9.33	11.54	13.53	12.12	3.96	7.18	4.32	4.74	5.73
SD+PM (3:1)	6.40	10.20	12.17	12.17	3.88	7.12	5.62	10.58	11.55
$LSD_{0.05}$	2.13	1.89	2.36	2.18	1.32	1.71	1.64	2.90	3.19

TS+PM+RS = Topsoil+Poultry Manure+Riversand; RS+PM+SD = Riversand+Poultry Manure+Sawdust; RH+PM+SD = Ricehusk+Poultry Manure+Sawdust; RH+PM = Ricehusk+Poultry Manure; SD+PM = Sawdust+Poultry Manure

The topsoil, rich in essential nutrients, such as nitrogen, is crucial for vegetative growth and leaf production (Darmody *et al*., 2009) could have been supplied by the medium. The addition of poultry manure could have further supplemented the nutrient supply, particularly nitrogen, phosphorus, and potassium, which are essential for plant growth and development (Ashworth *et al*., 2020). The inclusion of river sand must have improved the aeration, drainage, and root zone conditions, thereby facilitating optimal nutrient uptake and vegetative growth. TS + PM + RS (3:2:1) nursery medium has been recommended as the standard nursery medium. Maximum number of leaves had been reported in pawpaw by Shrivastava *et al*. (2021) with topsoil + farm-yard manure + sand + Vermicompost.

In contrast, medium containing high proportions of rice husk, that is RH+PM (3:1), consistently produced seedlings with the lowest number of leaves. This could be due to the high carbon-to-nitrogen ratio and potential nitrogen immobilization caused by the delayed decomposition of these organic materials (Hao *et al*., 2021; Depel *et al*., 2021). Nitrogen deficiency can inhibit leaf production and overall vegetative growth.

CONCLUSION AND RECOMMENDATIONS

Earliest seedling emergence, tallest seedlings and highest number of leaves were observed in TS+PM+RS (3:2:1) although there were no statistical variations with results obtained from the soilless-media, particularly RS+PM+SD (3:2:1), RH+PM+SD (1:1:1), RS+PM+SD (1:2:3), RH+PM (3:1) and SD+PM (3:1). Soilless-based nursery media such as RS+PM+SD (3:2:1), RH+PM+SD (1:1:1), RS+PM+SD (1:2:3) and RH+PM (3:1) can be deployed as alternatives to TS+PM+RS (3:2:1) for earlier emergence of seedlings and production of vigorous pawpaw seedlings in the nursery.

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Authors contributions

NOO and ONA conceptualized and provided the methodology of the study; Experimental set-up, data collection and collation was done by ICA; Validation and analysis of data were carried out by NOO; Writing of original draft preparation was done by ICA while rview and editing of manuscript was done by NOO and ONA.

Ethical statement

Not Applicable

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